REMARKS/ARGUMENTS

1. Specification

The Specification was amended by deleting Paragraphs **[0041]** and **[0042]**, and by amending Paragraphs **[0043]** and **[0044]**. The original Figures 9A and 9B described in paragraphs [0041] and [0042] were hand-written drawings that were not submitted with the application. Paragraphs [0043] and [0044] were amended to refer to Figures 9A and 9B as submitted. These amendments are proper as may be determined by comparing the first sentence in each with the description of these Figures in the Brief Description of the Drawings.

2. Claims

Claims 1-8 remain in this application. Claims 9-19 have been withdrawn as a result of an earlier restriction requirement. In view of the examiner's earlier restriction requirement, applicant retains the right to present claims 9-19 in a divisional application.

3. Previously Cited Art Enclosure

Applicants apologize for their failure to enclose the article by W. Bardsley and G.W. Green, "Optical scattering in calcium fluoride crystals", Brit. J. Appl. Phys. 1965, Vol. 16, pp. 911-912, that was cited by applicants in the immediately prior Response. A copy of the article is enclosed with this Response. In the event that Examiner does not receive the article, please contact the undersigned attorney and the article will be sent again.

4. § 103 Rejection

The Examiner has rejected claims 1-8 under 35 U.S.C. § 103(a) as being unpatentable for obviousness over Sakuma et al (6,377,322) in view of Hammond, et al (6,093,245).

A. Summary of the Rejection

Summarizing the Office Action, the Examiner asserts that Sakuma discloses an optical member for photolithography comprising a calcium fluoride crystal exhibiting an internal transmittance of 995%/cm or greater with respect to light transmitted from an F_2 laser (157 nm light). The Examiner admits that Sakuma does not disclose the chlorine concentration in the fluoride crystal.

Further summarizing, Hammond is cited for disclosing that high purity alkali metal halide material is useful as optical elements and that graphite has been used for growing calcium and barium fluoride crystals. However, while being able to withstand high temperatures, graphite is quite porous. When used as a crucible material for alkali metal growth the melt leaks through the crucible and upon cooling of the crystal they cannot be readily removed without damage to the crucible.

The Examiner goes on to state:

> "Sakuma '332 discloses a crucible comprising a vessel of porous carbon having a wall with a thickness, an outer surface, and an inner surface; a surface depth region of at least the inner surface being impregnated with additional carbon to close open porosity at the surface (note claim1). The porous carbon can be graphite (note claim 2) and the additional carbon can be graphite pyrolytic carbon (note claim 3) or glass carbon (note claim 4). The crucible can be used for growing calcium fluoride (note column 6, lines 23-32).
>
> 'Thus it would have been obvious to one of ordinary skill in the art at the time the invention was made to maximize the purity of the calcium fluoride disclosed by Sakuma '332 as suggested by Hammond'245. Also it would have been obvious to one skilled in the art to use the crucible of Hammond '245 in the process of producing calcium fluoride of Sakuma '332 because such crucible would permit release of the cooled crystal without remelting (note abstract), since graphite was not in contact with

the crystal, any chloride impurity in the graphite would not mitigate to the crystal itself."

The Examiner then concluded that the arguments presented y applicants in their Response filed on July 25, 2005 were not persuasive. Although applicants did not enclose the Bardsley/Green article with the prior response, based on applicants' statements that they teach that when impurities, including chlorine, are too high, the transmission of the calcium fluoride below 200 nm would not be as high as applicants' claims required. However, the Examiner asserts that Sakuma '332 discloses a calcium fluoride crystal having an internal transmittance of 99.5% or greater with respect to light emitted from an F_2 laser; and the Examiner concludes that thus the amount of impurities in the calcium fluoride, including chlorine impurity, as disclosed by Sakuma '332 would be inherently low as required by applicants' claims.

With regard to applicants' argument that Sakuma did not realize that the chloride level in calcium fluoride was a source of scatter, the Examiner replies that even if Sakuma did not realize this, "when the transmittance of the calcium fluoride in Sakuma '332 is the same as that of [applicants'] claimed product, the calcium fluoride of Sakuma '332 is considered as "scatter-free" and it would inherently has low chlorine or chloride level."

Finally, the Examiner states that Hammond is applied to teach that in order to produce highly pure crystals, such as those made of an alkali metal material, for use in an optical application, a crucible such as described in Hammond is used to facilitate removal of the crystal. Since the crystal product of Sakuma is also used in an optical application and is required to have high purity to reduce the scattering effect, it would have been obvious for one of ordinary skill in the art to use the crucible as suggested by Hammond to produce the crystal product of Sakuma.

Applicants traverse the rejection.

B. <u>Applicants' Reply to the Rejection</u>

I. Prior Response

Applicants incorporate by reference the facts and arguments set forth beginning on page 5 of their prior Response filed on July 25, 2005. [Note: on page 5, third paragraph, second line, the phrase "with regard to the fluoride content of the CaF_2 crystal" should read "with regard to the **<u>chloride</u>** content of the CaF_2 crystal"

II. This Response to the Office Action mailed November 17, 2005.

First, applicants submit that the Rejection is improper because the Examiner draws conclusions from Sakuma '332 that are not supported by the patent. In particular, the Examiner states that because Sakuma an *internal transmittance* of greater than 99.5% the crystal of Sakuma must have a low chloride level. *The Examiner is making an invalid assumption that the chloride level in Sakuma '332 must be the same as that of the claimed invention.* Sakuma does not mention chloride levels and any assumption that the chloride level in the Sakuma crystals is the same as in applicants' crystals is pure speculation as will be further explained below. Such speculation cannot be the basis for an obviousness rejection. Therefore, applicants submit that Sakuma '332 does not teach or suggest the claimed invention

Second, the Examiner has assumed that applicants' transmittance and that of Sakuma are the same. This is incorrect. As applicants state in their specification and in claim 3, crystals containing less than <0.25 ppm Cl have a <200 nm transmission of >99%. In contrast to applicants' invention, in column 7, lines 20-23, Sakuma '332 states that the crystals claimed therein has an ***internal transmission*** of 99.5% and an ***overall transmission*** of approximately 89.5%. Sakuma is very careful to distinguish internal transmission from overall transmission. Sakuma attributes the difference to reflectance. However, since Sakuma is not aware of the influence chloride can have on transmission through a crystal by producing scattering, such scatter losses may constitute part of the losses Sakuma attributes to reflectance. Note that in Column 7, lines 23-26, Sakuma further states that even if the ***internal transmittance*** is 100%, then transmittance taking

into account reflection loss is 90.9% regardless of the substrate thickness. With this statement Sakuma is saying that the maximum transmittance one can obtain with a calcium fluoride crystal of any thickness is 90.9%. This statement teaches away from the claimed invention as described applicants' specification and claimed in claim 3 wherein applicants claim (in combination with base claim 1) a crystal having a transmission of >99% and a chloride level of <0.25 ppm. Consequently, applicants submit that Sakuma '332 again does not teach or suggest the claimed invention.

Third, applicants now refer the Examiner to applicants' Figure 16 and Paragraph [0058]. As illustrated in Figure 16, the crystals C#1, C#2 and C#3 are stated as having "No Scatter". In each of these crystals the Cl level is less than the 0.25 ppm level claimed in applicants' claim 1. Crystal C#4 however does produce scatter and the Cl level in this crystal is 0.3 ppm which is above the 0.25 ppm level of claim 1.

There is no reference in Sakuma '32 as to the chloride level present in the crystals described therein. However, in column 7, lines 20-26, Sakuma clearly states that the maximum transmission level through a calcium fluoride crystal, even one having 100% internal transmittance, is approximately 90%. He attributes the approximately 10% difference between the internal transmittance and overall transmittance to reflection losses. However, since Sakuma is unaware of the effect that chloride can have on a crystal by producing scatter, it is arguable that a substantial part of what Sakuma attributes to reflection losses is actually due to scatter produced by chloride in the crystal.

Applicants' data as shown in Figure 16 and explained in Paragraph [0058] clearly indicate that scatter is produced at a chloride level of 0.3 ppm. *Arguendo*, the crystals of Sakuma probably contain a chloride level greater than 0.25 ppm and the scatter produced by this chloride could account for the overall losses Sakuma reports for their crystals.

Applicants' Figure 9A illustrates a CaF_2 crystal in normal (room) light. Figure 9B illustrates a crystal in which the normal light has been turned off and a red laser inspection light is passed through the crystal. Figure 9B clearly shows the scatter that is present in the crystal. As applicants explain in Paragraph [0044]: "*In a scatter-free*

calcium fluoride disk blank one would not see any red streak in the crystal since there would be nothing to ***reflect or scatter*** *the light in the middle of the crystal."*

Applicants submit that the facts that (a) Sakuma is unaware of the effect of chloride in transmission, and (b)that the scatter produced by chloride in a crystal can reduce transmission as shown by applicants, and (c) that Sakuma clearly states that overall transmittance of his claimed crystals is approximately 90% (column 7, lines 20-26) is due to "reflectance losses" clearly indicate that Sakuma '332 does not teach or suggest the claimed invention.

Fourth, with regard to Sakuma in view of Hammond '245, applicants incorporate by reference the arguments set forth in their Response of July 25, 2005. In particular, applicants submit that since Hammond purifies crucibles using a high temperature chlorine treatment, the use of such crucibles would tend to increase the chlorine content of any calcium fluoride crucible grown in such crucibles. Consequently, since both Hammond and Sakuma do not teach or suggest that chloride can have a detrimental effect on crystals used for <200 nm light transmission, and since Sakuma clearly indicates that his crystals have an overall transmittance of approximately 90%, and since applicants have clearly indicated that chloride can account for all or part of the approximately 10% transmission losses acknowledged by Sakuma; applicants submit that the combination of Hammond and Sakuma does not teach or suggest the claimed invention.

4. Conclusion

Based upon the above amendments, remarks, and papers of records, applicants believe the pending claims of the above-captioned application are in allowable form and patentable over the prior art of record. Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

Applicant believes that no extension of time is necessary to make this Reply timely. Should applicant be in error, applicant respectfully requests that the Office grant such time extension pursuant to 37 C.F.R. § 1.136(a) as necessary to make this Reply timely, and hereby authorizes the Office to charge any necessary fee or surcharge with

respect to said time extension to the deposit account of the undersigned firm of attorneys, Deposit Account 03-3325.

If the Examiner has any questions or comments whose resolution would further prosecution, please call applicants' attorney of record, Water M. Douglas, at telephone number 607-974-2431.

Respectfully submitted,

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CERTIFICATE OF TRANSMISSION

UNDER 37 C.F.R. § 1.8

I hereby certify that this paper and any papers referred to herein are being transmitted by facsimile to the U.S. Patent and Trademark Office at 703-872-9306 on:

17 January 2006
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Walter M. Douglas 17 Jan 2006
Date

BRIT. J. APPL. PHYS., 1965, VOL. 16

Optical scattering in calcium fluoride crystals

Abstract. It is generally believed that scatter in calcium fluoride crystals is invariably caused by calcium oxide. Evidence is presented which shows that chlorine or sulphur can also cause scatter and that they are the source of the residual scatter sometimes observed in single crystal material doped with rare earth elements.

Scatter, caused by particles of the order of 1 μm diameter, has been a major problem in the production of calcium fluoride laser crystals of the highest quality.

Stockbarger (1949) attributed scatter in CaF_2 to the presence of calcium oxide and used additions of lead fluoride (purging) to remove oxygen by the reaction

$$CaO + PbF_2 = CaF_2 + PbO\uparrow$$

We believe scatter may have several different causes; certainly gross contamination of the gas atmosphere by water vapour and air can cause the effects noted by Stockbarger. The purpose of this letter is, however, to report evidence which suggests that sulphur and chlorine are more probably the causes of the residual scatter which is often experienced.

In this laboratory single crystals of calcium fluoride have been grown by pulling from the melt with an apparatus previously described by Cockayne *et al.* (1964) but with the silica envelope water-cooled to avoid reaction with calcium fluoride vapour. The starting charge usually was purged lump mineral fluorite (obtained from Barr and Stroud Ltd). Pulled from a vitreous carbon crucible (obtained from The Plessey Co., Ltd) in an atmosphere of dried purified argon, the undoped material normally yielded crystals in which the scatter was too small to be measured by the method of Kaiser and Keck (1962) (extinction scattering coefficient $<0{\cdot}005\ cm^{-1}$) and was not visible to the eye in a strong beam of light. Any scatter which was detectable was reproducibly characteristic of the particular batch of fluorite used.

In order to check whether surface contamination could introduce sufficient oxygen to cause scatter the starting charge was exposed to the atmosphere for up to two days. It was also boiled in water for up to 2 hours. In both cases such treatment did not cause any additional scatter in the crystals.

However, by doping calcium fluoride with various materials we were able to elucidate certain sources of scatter. Between 60 and 200 parts per million of oxygen added as calcium oxide to the melt was necessary to cause detectable scatter; rather less than this amount gave rise to a characteristic red fluorescence when the crystal was illuminated with white light. On the other hand scatter was not observed when the crystals were doped with rare earth oxides at concentrations of up to 3%, which was the maximum amount added. It is interesting that enough divalent samarium was present in crystals doped with 0·1% samarium oxide for laser action to be obtained (Forrester, Green and Sampson 1965).

When sulphur was added to the melt at a concentration of 20 parts per million in the form of CaS or $CaSO_4$ detectable scatter was produced. The scattering centres were in the form of hexagonal platelets orientated in (111) planes and similar to those observed by Stepanov and Feofilov (1956, p. 181). Such platelets were also observed in undoped crystals annealed under vacuum in a graphite tube. These crystals had a faint characteristic smell of H_2S and, indeed, analysis showed they contained some 20 parts per million of sulphur. The platelets did *not* appear in crystals annealed in a sulphur-free vitreous carbon tube.

Scatter was also observed to a variable extent in crystals doped with rare earth fluorides. Dysprosium fluoride has been particularly troublesome and analysis has shown that up to 0·4% of chlorine was present, with only trace quantities of other elements. When chlorine was added to the pure melt at concentrations of 50 parts per million in the form of anhydrous